UNCLASSIFIED

AD NUMBER
AD809556
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 03 MAR 1967. Other requests shall be referred to Rome Air Development Center, Griffiss AFB, NY.**
AUTHORITY
RADC ltr 17 Sep 1971

THIS PAGE IS UNCLASSIFIED

CONTINUED STUDIES ON ADVANCED FERRIMAGNETIC MATERIALS APPLIED TO DIGITAL PHASE SHIFTERS

FOURTH QUARTERLY REPORT

29 November 1966 through 3 March 1967

ARPA ORDER NO. 550
PROGRAM CODE NO. 6E30

SPERRY
MICROWAVE ELECTRONICS COMPANY
CLEARWATER, FLORIDA

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of RADC (EMLI) Griffiss AFB NY 13440.

TECHNICAL REPORT

CONTINUED STUDIES ON ADVANCED FERRIMAGNETIC MATERIALS APPLIED TO DIGITAL PHASE SHIFTERS

FOURTH QUARTERLY REPORT

29 November 1966 through 3 March 1967

ARPA ORDER NO. 550

PROGRAM CODE NO. 6E30

CONTRACTOR:	SPERRY MICROWAVE ELECTRONICS COMPANY
DATE OF CONTRACT:	28 February 1966
AMOUNT OF CONTRACT:	$146,794.00
CONTRACT NUMBER:	AF30(602)-4122
CONTRACT EXPIRATION:	3 March, 1967

SPERRY MICROWAVE ELECTRONICS COMPANY
DIVISION OF SPERRY RAND CORPORATION
CLEARWATER, FLORIDA

SJ-220-4002-5

I. Introduction

1.1 Background

During the course of the previous program, entitled "Advanced Ferrimagnetic Materials Applied to Digital Phase Shifters", a considerable amount of information was accumulated on ferrite digital phase shifter materials and structures. The square loop and microwave properties of many ferrimagnetic garnets and ferrites were investigated. Structures employing these materials were also evaluated at both low and high power levels. The investigations were made principally in the 3 to 10 GHz frequency range.

The purpose of the present program is to derive a number of ferrimagnetic materials for use at high power levels below 3 GHz. Since it is unlikely that the low frequency structures will be basically different than those used at frequencies above 3 GHz, improvement in the phase shifter operating characteristics will probably depend primarily on improvements in the materials.

1.2 Program Objectives

The objectives of this program are directed toward the improvement and evaluation of ferrite and garnet materials for use in digital phase shifters. Effort will be applied in the following areas:

1.2.1 Improvement and evaluation of ferrite and garnet materials for use in digital phase shifters at L-, S-, C- and X-bands will be pursued with increased effort at the lower frequency bands. Emphasis will be placed on development of peak power capability of the order of 100 kilowatts while generating insertion losses of 1 db or less and phase stability with temperature variation over the military range.

1.2.2 Microwave digital phase shift structures will be studied with special emphasis on materials derived in this program combined with the requirements for high switching speed, low switching power, low loss, low holding power, compact configuration, low unit cost, and high peak and average power handling capability.

1.3 Assignment of Responsibility for the Program

This program is assigned to the Engineering Department of the Sperry Microwave Electronics Company. Dr. R. E. Henning is the Chief Engineer. Overall responsibility for the program is in the Microwave Equipment Department with Mr. B. J. Duncan, Engineering Manager. Direct responsibility for the program is in the Research Section with Dr. G. R. Harrison, Section Head. Mr. D. R. Taft, Senior Staff Engineer, is the Project Engineer and is also responsible for the rf evaluation of the materials and the structures. The materials investigations in the program are being conducted by Mr. L. R. Hodges, Senior Staff Engineer, and Mr. W. R. Wilson, Engineer. Consulting services will be provided by Dr. G. P. Rodrigue and Dr. J. L. Allen of the Research Section.

II. Narrative summary of Work Performed from 29 November 1966 through 3 March 1967

The tasks outlined in the First Quarterly Report of this contract have been essentially completed. Samples of several different type garnet and ferrite materials were fabricated and their microwave and square loop properties were measured. The materials were then machined to the appropriate sizes and evaluated in waveguide structures at low and high power levels at X-band (8.0 - 10.0 GHz), C-band (5.0 - 6.0 GHz), and at low power levels at L-band (1.2 - 1.6 GHz). Some materials were also tested at low power levels in a helix structure in the 1.0 to 3.4 GHz frequency range and are presently being tested at high power levels.

During this quarter the L-band waveguide and helix measurements were performed. Because of the large sizes required, the toroids for the waveguide structure had to be pieced together. Nevertheless, the remanence ratios obtained were moderately good varying from a low of 0.24 to a high of 0.56.

The results obtained in the waveguide structure for normal operation (operating frequency greater than the resonant frequency, i.e. $f_{op} > f_{res}$) were in good agreement with the predictions from the computer program. The losses varied from about 0.90 db per 360° for aluminum substituted YIG to about 1.10 db per 360° for 15 percent gadolinium, aluminum substituted YIG at $m_s \approx 0.66$.

Measurements made in the helix in below resonance operation ($f_{op} < f_{res}$)

have shown that this type of operation is possible. It appears that to be feasible the ferrite material must possess low resonance linewidth and very high remanence ratio. Remanence ratios approaching unity may, in fact, be required in order that the device can be operated close enough to resonance to obtain high differential phase shift.

The results obtained in the waveguide structure for $f_{op} < f_{res}$ were were less encouraging than anticipated. The loss corresponding to the $-M_r$ state increased drastically with decreasing frequency (which may have been waveguide cutoff losses) while the losses in the $+M_r$ state increased with increasing frequency due to the ferrimagnetic resonance losses. The resonance losses extended much lower in frequency than was anticipated so that the losses were generally quite high (> 10 db) at all frequencies examined.

This is the final quarter of the program and the technical effort has been essentially completed. Presently the accumulated data are being re-evaluated and reduced for incorporation into the Final Report. The actual writing of the Final Report will then commence as scheduled.